DOCUMENT RESUME

ED 092 394 SE 017 965

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TITLE The Effects of Adopting the Revised New York State Regents Earth Science Syllabus on Selected Teacher and Student Variables.
INSTITUTION State Univ. of New York, Buffalo.
SPONS AGENCY Office of Education (DHEW), Washington, D.C.
PUB DATE Jun 73
NOTE 20p.

EDRS PRICE MF-$0.75 HC-$1.50 PLUS POSTAGE
DESCRIPTORS *Curriculum; *Earth Science; *Educational Research; Science Education; *Science Teachers; *Secondary School Science
IDENTIFIERS *Curriculum Adoption; Curriculum Implementation; New York State Regents Earth Science Syllabus; Research Reports

ABSTRACT

This study investigated the effect voluntary or mandatory adoption of the Earth Science curriculum had on instructional procedures, teacher educational opinion, student achievement in earth science, and student ability to employ the processes of science. Selection of teachers resulted in three groups: (A) those forced to adopt the new syllabus, (B) those who voluntarily adopted the new syllabus, and (C) those who helped develop the syllabus. Both cross-sectional and longitudinal (pre-post) designs were used to test hypotheses formed. Data were collected from students and teachers. Adoption of the new syllabus did effect the predicted changes. Group A teachers did not employ teaching behaviors advocated to the same degree as did teachers from Groups B and C. Some fluctuations of teacher educational opinions did occur on initial experience with the new syllabus, but overall this variable seemed to be relatively stable, with differences across groups being detected. Results of tests suggested students perform best on the tests designed for the syllabus used by their teacher. The study failed to detect differences across groups or time with respect to student ability to employ the processes of science. (Author/EB)

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ED 092394

The Effects of Adopting the Revised New York State Regents Earth Science Syllabus on Selected Teacher and Student Variables*

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June, 1973

*The project reported herein was performed pursuant to a grant from the U.S. Office of Education, Department of Health, Education and Welfare. The opinions expressed herein, however, do not necessarily reflect the position or policy of the U. S. Office of Education, and no official endorsement by the U.S. Office of Education should be inferred.

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INTRODUCTION

Sawin (1) has urged that summative evaluation of new curricula should begin with the stated objectives of the curriculum developers. Among the major objectives of the new science curricula which dominated science education in the sixties, two stand foremost: (2)

1. The purpose of instruction is to develop an understanding of current scientific knowledge, its concepts and methods of inquiry.
2. The instructional process itself is to become more laboratory centered and inquiry oriented. Laboratory instruction is to become less illustrative and more investigative.

Welch, (3) has shown that summative evaluation of the new science curricula has been quite limited, both in the number of studies devoted to such evaluation, and in the scope of the studies which have been undertaken. Those studies which have been undertaken, have focused primarily on outcomes related to the first of the two objectives listed above. They have been primarily concerned with evaluating curriculum effects on student cognitive development.

In their reviews of science education research in the sixties, Ramsey and Howe (4) and Balzer (5) reported very few studies concerned with the effects which the new science curricula were having on instructional procedures employed by science teachers. In the absence of research data, educators such as Silberman (6) and Hurd (7) have asserted that adoption of the new science curricula has had an insignificant effect on instructional procedures employed by science teachers. Considering the magnitude of the science curriculum reform movement, and considering the importance which

the curriculum reformers attached to changing instructional strategies, it seems incredible that evaluation of such change remains largely a matter for speculation. Research in this area is badly needed.

Nearly all evaluation of the new science curricula which has been done, has compared teachers or students using one of the new curricula with teachers or students using a traditional curriculum, and has then attributed any differences discovered to the use of the new curriculum. Since in most cases, teachers and students are not randomly assigned to treatment or control groups, it is quite possible that selection effects account for much of the difference discovered between groups. Teachers who choose to teach one of the new science curricula may very well have been teaching more "progressively" and more effectively all along than teachers who chose to continue using a traditional curriculum (cf. Gallagher, 8). Random assignment of teachers and classrooms to the utilization of "new" and "traditional" curriculum materials is rarely practicable, particularly if reasonably large samples are desired. An alternate method of controlling for selection effects consists of using a pre-post design. The desired classroom variables are measured both before and after adoption of the new science curriculum. Changes discovered in this way can be assumed to be relatively unaffected by selection effects. The study to be reported in these pages employed both the group comparison and the pre-post design, and thus is able not only to evaluate the effects of adopting a new science curriculum, but is also able to assess the effects of selection factors on such an evaluation process.

The curriculum selected for this evaluation was the revised version of the New York State Regents Earth Science Syllabus. The "control" curriculum was the regular (1959) version of the Regents Earth Science Syllabus.

That the developers of this curriculum sought to attain the objectives which guided the curriculum reform movement of the sixties is clear from the guidelines established for development of the new syllabus by the Revision Committee for the Regents Earth Science Syllabus. (9) This committee determined that the new syllabus should be:

1. Student activity oriented - Students should be exposed to a learning environment in which they would be active participants. Laboratory and field experience should be the focal point of this program.

2. Investigatory in approach - The learning activities should be oriented toward an inquiry approach, placing the student in the role of investigator.

3. Interdisciplinary in content - The course content organization should integrate the traditional earth science subject areas. Emphasis should be placed on the analysis of the environment, and the processes affecting it. (p. iii)

Evaluation of this curriculum was directed by the guidelines established here. Since teaching strategies were particularly stressed, and since this facet of curriculum evaluation has been very lightly researched, the present study focuses especially on the effect which adoption of the new curriculum had on instructional procedures.

The Problem

This study seeks to determine whether adoption of the new earth science curriculum led to:

1. use of teaching behaviors which were more in accord with the objectives of the curriculum developers;

2. expression of more progressive educational opinions by the teachers involved;

3. higher achievement by students on a test of the "new" earth science knowledge;

4. increased ability of students to recognize and apply the processes of science.

The first, third and fourth effects of adopting the new curriculum are directly related to the stated objectives of the curriculum developers.

It was considered that the second effect, teacher educational opinion, was related to adoption and use of the new science curricula. For this reason an assessment of teacher educational opinion is sought in this summative evaluation of the revised Regents Earth Science Syllabus.

Populations and Samples

About one hundred fifty Regents Earth Science teachers participated in the development of the revised version of the syllabus between 1965 and 1970. During these years, only those teachers actively engaged in the revision process were permitted to use the preliminary version of the revised syllabus. In 1970, all Regents earth science teachers were permitted to use the new materials if they wished. In 1971, the revised version replaced the traditional version of the syllabus for all teachers of Regents Earth Science. In the fall of 1970, therefore, there were three populations of Regents earth science classrooms in New York State:

A. Classrooms whose teachers chose to continue teaching the traditional version of the syllabus;

B. Classrooms whose teachers chose to begin teaching the new syllabus when its adoption was optional;

C. Classrooms whose teachers had participated in the development of the new syllabus, and continued to teach the revised version in the fall of 1970.

In the summer of 1970, lists of the teachers in each of these populations were made available to the researcher by the Bureau of Science Education of the State Education Department. Statewide samples were randomly selected to receive an invitation to participate in the study. Approximately one-third of those invited consented to participate in the anticipated two year study: thirty-eight from Population A, forty-one from Population B, and thirty-nine from Population C. These groups constituted the samples used in the study. For each teacher, the researcher selected one section of Regents earth science students to participate in the study. Data collection began in late October, 1970.

Instruments

Teaching behaviors were assessed by means of the Earth Science Classroom Activity Checklist. (10) This instrument was adapted for use in the earth science classroom from Kochendorfer's Biology Classroom Activity Checklist (11) and Barnes' Biology Laboratory Activity Checklist. (12) The instrument used in this study has eighty-seven items, most of which describe a behavior that is either advocated or discouraged by the developers of the new science curricula. The student reports the frequency of the occurence of these behaviors in his classroom by responding to a five point scale, which ranges from "very often" to "hardly ever". In the scoring process, a response of "very often" relative to an advocated teaching behavior was given a value of 5; "hardly ever" was scored as 1. Relative to a teaching behavior whose frequent use was discouraged, "very often" was scored as 1, "hardly ever" was scored as 5. (Intermediate responses were scored as 2, 3, or 4.) Thus, high scores indicate frequent utilization of the behaviors desired by the curriculum developers, and infrequent use of behaviors discouraged by these developers. The mean response for each item, and for the overall instrument was calculated for each classroom at each administration of the instrument.

Teacher educational opinion was assessed by means of the Educational Opinion Scale. (10) The researchers wished to assess both general educational opinion, and educational opinions specific to the science classroom. Since no single instrument was located which measured both aspects of educational opinion, the researchers combined Kerlinger and Pedhazur's Educational Scale VII (13) and Schirner's Teacher Educational Credo Preference Checklist (14) into a single instrument. Educational Scale VII measures general educational opinion on the basis of agreement or disagreement with educationally progressive or conservative statements. The Teacher Educational Credo Preference Checklist measures educational opinions relative to the science

classroom on a "non-traditional/traditional" scale.

Responses to the Educational Opinion Scale ranged from "strongly agree" to "strongly disagree" on a five point scale. High scores on this instrument were obtained by agreement with progressive and non-traditional statements, and by disagreement with conservative and traditional statements.

Student achievement on tests of earth science knowledge was measured by means of a researcher devised Earth Science Test. This instrument consisted of two sets of items, each devised to measure outcomes appropriate to one or the other of the two regents earth science syllabi. This test provided mean "new content" and "old content" subscores for each classroom. Scores reported are the mean proportion of correct responses for the class on the items of each subtest.

Student ability to recognize and apply the processes of science was assessed by administering the Processes of Science Test. (15) Scores reported are the raw classroom mean scores on twenty-nine items on this test.

Hypotheses

As indicated earlier, the present study employed two designs: across groups (cross sectional) and pre-post (longitudinal). Research hypotheses relative to each of the variables measured were tested under both designs.

I. Hypotheses relating to comparisons between groups:

1. Teachers using the new syllabus will employ teaching strategies more in conformity with those advocated by the developers of the new syllabus than those employed by teachers using the traditional syllabus. (In 1971, Groups B and C combined will have higher scores on the Activity Checklist than will Group A.)

2. Teachers who helped develop the new syllabus will initially hold educational opinions which are more progressive than those of other teachers. (Group C will have a higher score in the fall of 1970 than groups A and B combined.)

3. Students whose teachers use the new syllabus will obtain higher scores on a test designed for the new syllabus than will students of teachers using the traditional syllabus. Students whose teachers use the traditional syllabus will obtain higher scores on a test designed for the traditional syllabus than will students whose teachers use the new syllabus. (On the "new content" subscore of the 1971 Earth Science Test, students in Group B and Group C classroom will outperform students in Group A Classrooms. On the "old content" subscore, students in Group A Classrooms will outperform students in Group B and Group C Classrooms.)

4. Students whose teachers use the new syllabus will make greater gains in their ability to recognize and apply the processes of science than will students whose teachers use the traditional syllabus. (When spring POST scores are adjusted for fall POST scores, students in groups B and C will obtain higher scores than will students in Group A, during the year 1970-71.)

II. Hypotheses relating to longitudinal comparisons within groups:

1. After they begin to use the new syllabus, teachers will begin to employ teaching procedures more in accord with the objectives stated by the developers of the new syllabus. (Teachers in Group A will obtain higher Activity Checklist scores in 1972 than they did in 1971).

2. Teachers who begin to use the new syllabus will begin to express educational opinions which are more progressive than the opinions they previously expressed. Extended use of the new syllabus will lead to expression of increasingly progressive opinions. (Teachers in Group A will obtain a higher score on the Opinion Scale in 1971-72 than they did in 1970-71. Teachers in all groups will express more progressive opinions in the spring of 1972 than they did in the fall of 1970.)

3. When teachers begin teaching the new syllabus, their students will perform better on tests of the new material, and worse on tests of the traditional material than their students did when they were using the traditional syllabus. (Students of Group A teachers will obtain higher "new content" and lower "old content" subscores in 1972 than in 1971.)

4. After teachers begin using the new syllabus, their students will make greater gains in their ability to recognize and apply the processes of science than did their students when they were using the traditional syllabus. (When spring POST scores are adjusted for fall POST scores, students of Group A teachers will obtain higher scores in 1972 than did students of these same teachers in 1971.)

Data Collection Schedule

The Activity Checklist and the Earth Science Test were administered in all classrooms of teachers participating in the study during May of 1971 and May of 1972. The teachers responded to the Educational Opinion Scale, and the students completed the Processes of Science Test in November and May during each year of the study. All tests were administered by the classroom teachers, according to instructions supplied by the researchers. All scoring and analysis was done by the researchers.

Results

An α level of .05 was selected for rejection of the null hypothesis related to each of the research hypotheses listed above. F ratios and t-values are marked by an asterisk in the following tables if the test showed significance; ns marks non-significant tests.

I. Results of analyses of data collected to test hypotheses making comparisons between groups:

1. Table 1 shows that hypothesis I-1 was supported by analysis of the data. Teachers using the new syllabus differed significantly, in the predicted direction, from teachers using the traditional syllabus on the overall Activity Checklist Score. Item analysis, reported elsewhere (10) indicates that the course taught in 1970-71 by teachers in Groups B and C was more laboratory oriented, more open-ended and discovery oriented, and was more interdisciplinary in nature than that taught by Group A teachers in the same year.

TABLE 1

PLANNED INDEPENDENT CONTRASTS - GROUP A VS GROUPS B&C
ACTIVITY CHECKLIST, OVERALL SCORES, SPRING 1971

Means			SS		
A	B	C	Compare	MSW	F Ratio
3.05	3.49	3.51	4.84	.0389	124.30*

Degrees of Freedom: 1,102

2. Table 2 shows that hypothesis I-2 was supported by analysis of the data. The initial opinions of teachers who had helped develop the new syllabus were significantly more progressive than those of teachers who had not participated in development of the syllabus.

TABLE 2

PLANNED INDEPENDENT CONTRAST ON OPINION SCALE
FOR GROUP C VS GROUP A & B, FALL 1970

Means			SS		
A	B	C	Compare	MSW	F Ratio
3.70	3.76	3.94	1.17	.081	14.55*

Degree of Freedom: 1,102

3. Table 3 shows that hypothesis I-3 was supported by analysis of the data. Students of teachers using the new syllabus did significantly better on the "new content" subtest than did students of teachers using the traditional syllabus. Students of teachers using the traditional syllabus did significantly better on the "old content" subtest than did students of teachers using the new syllabus.

TABLE 3

PLANNED INDEPENDENT CONTRASTS, GROUP A VS GROUPS B & C
EARTH SCIENCE TEST SUBSCORES, SPRING 1971

	Means			Mean Square		
Subscore	A	B	C	Hypothesis	MSW	F Ratio
"Old Content"	.540	.458	.431	.213	.0072	29.24*
"New Content"	.519	.564	.558	.043	.0045	9.44*

Degree of Freedom: 1,102

4. Table 4 shows that hypothesis I-4 was not supported by analysis of the data. When spring POST scores were adjusted for fall POST scores, students of teachers using the new syllabus did not score significantly higher on POST than did students of teachers using the traditional syllabus. In results reported elsewhere (10), it was found that none of the groups significantly differed from one another in respect to their adjusted POST scores during either year of the study.

TABLE 4

ANALYSIS OF COVARIANCE OF MEANS ON PROCESSES OF SCIENCE TEST FOR ALL GROUPS, 1970-71

Group	Treatment Mean	Adjusted[1] Mean	Mean Square Adjusted M	Mean Square Within	F Ratio
A	17.18	17.71			
B	18.33	18.20	7.58	4.99	1.52 ns
C	17.67	17.26			

Degrees of Freedom: 1,102

[1] Spring scores adjusted for Fall scores

II. Results of analyses of data collected to test hypotheses making longitudinal comparisons within groups.

1. Table 5 shows that hypothesis II-1 was supported by analysis of the data. Teachers in Group A received significantly higher overall scores on the Activity Checklist in 1972 after they began use of the new syllabus than they received prior to this adoption in 1971. Item analysis, reported elsewhere (10) indicates that the course these teachers taught in 1971-72 was more laboratory centered, more concerned with discovery and more open-ended than the course they had taught in the previous year, when using the traditional syllabus.

TABLE 5

T-TEST OF DIFFERENCE OF MEANS ON ACTIVITY CHECKLIST OVERALL SCORE FOR GROUP A, SPRING 1971 TO SPRING 1972

Mean Difference	t-Value	Degrees of Freedom
.2173	5.5605*	27

2. Table 6 shows that hypothesis II-2 was supported by analysis of Opinion Scale data collected from Group A teachers in the fall of each year of the study. (Note "1" in table 6.) After they began to use the new syllabus in the fall of 1971, teachers in Group A expressed significantly more progressive educational opinions than they had expressed in the fall of the previous year, when using the traditional syllabus. Reference to table 6, however, will show that when spring opinions are compared with spring opinions, (2), or when spring 1972 opinions are compared with fall 1970 opinions, (3) the differences in educational opinions expressed by this group are not significant. Table 6 also shows that the educational opinions expressed by each of the other two groups did not significantly change from the fall of 1970 to the spring of 1972, (4,5). (Table C: 4 5)

TABLE 6

T-TEST OF DIFFERENCES ON EDUCATIONAL OPINION SCALE BY GROUPS, THROUGH SELECTED TIME INTERVALS

GROUP A

Time Interval	Difference	t-Value	Degrees of Freedom
1) Fall 1970-Fall 1971	.1125	2.2817*	25
2) Spring 1971-Spring 1972	-.0036	-.1276 ns	22
3) Fall 1970-Spring 1972	.0070	.1640 ns	26

GROUP B

	Time Interval	Differences	t-Value	Degrees of Freedom
4)	Fall 1970-Spring 1972	-.0050	-.1779 ns	27

GROUP C

5)	Fall 1970-Spring 1972	-.0224	-.7244 ns	25

3. Table 7 shows that Hypothesis II-3 was only partially supported by analysis of the data. Students of teachers who adopted the new syllabus in 1971 did significantly worse on the "old content" than did students of these same teachers when the teachers used the traditional syllabus. There was no significant difference, however, on the "new content" subtest between these two groups of students.

TABLE 7

T-TEST OF DIFFERENCES ON EARTH SCIENCE SUBTESTS FOR GROUP A BETWEEN SPRING 1971 AND SPRING 1972

Subscore	1971 Mean	1972 Mean	Difference of Means	t-Value
New Content	.518	.529	.011	.9102 ns
Old Content	.531	.453	-.078	-4.8814*

Degrees of Freedom = 27

4. Table 8 shows that hypothesis II-4 was not supported by analysis of the data. The adjusted POST scores of students of teachers who adopted the new syllabus in 1971 did not differ significantly from the adjusted POST scores of students of these same teachers when they were using the traditional syllabus.

TABLE 8

ANALYSIS OF COVARIANCE OF MEANS ON PROCESSES OF SCIENCE TEST FOR GROUP A 1970-71 VS GROUP A 1971-72

Year	Treatment Mean	Adjusted[1] Mean	Mean Square of Adjusted Means	Mean Square Within	F Ratio
1970-71	17.39	17.34	.26	3.89	.66 ns
1971-72	17.18	17.21			

Degrees of Freedom = 1, 60

[1]Spring POST scores adjusted for fall POST scores

Discussion

Combining the findings reported under both designs employed in this study leads to several conclusions.

Not only did the teaching strategies employed by teachers using one of the new science curricula differ from those of teachers not using this curricula; teachers who adopted one of the new science curricula were found to change their teaching procedures following curriculum adoption in such a way as to include more of the behaviors advocated by the developers of the curriculum. Table 9 shows, however, that subsequent to this change, the teachers newly adopting the revised syllabus still employed behaviors significantly less in accord with the advocated behaviors than those employed by teachers who had earlier adopted the new syllabus.

TABLE 9

PLANNED INDEPENDENT CONTRASTS ON ACTIVITY CHECKLIST OVERALL SCORE FOR GROUP A VS GROUPS B & C, SPRING 1972

Means			SS		
A	B	C	Compare	MSW	F Ratio
3.30	3.49	3.47	.607	.031	19.52*

Degrees of Freedom : 1, 89

This residual difference between those who volunteer and those who are mandated to teach the new science curriculum, in respect to teaching strategies employed, is most likely a selection effect. Those who volunteered to teach the new syllabus when its use was optional almost certainly brought with them teaching strategies which were more in accord with the objectives of the new curriculum developers than were the strategies employed by those who chose to continue using the traditional materials as long as these were available.

The interesting and important conclusion remains, however. Mandated adoption of one of the new science curricula did lead to more frequent employment of the teaching behaviors advocated by that curriculum. This finding should be a source of encouragement to the many teachers and science educators who participated in the revision of the Regents Earth Science Syllabus. They have produced a curriculum which has brought about a change in the teaching procedures used in the Regents earth science classrooms of New York State.

When the findings of this study are considered in conjunction with the similar findings of Kochendorfer (11) and Barnes (12), it seems likely that the new science curricula generally are bringing about desired changes in the teaching behaviors employed by the teachers who adopt them. More research needs to be done, however, to determine which conditions of adoption tend to optimize changes in teaching strategy. More research is also necessary to determine whether teachers continue to use the advocated methods in subsequent years, and if so, whether they tend to employ them more frequently as they gain more experience with the new curriculum.

The increase in progressive opinions expressed by teachers adopting the new syllabus may be attributed to a burst of enthusiasm which they experienced as they replaced their traditional curriculum with a new

instructional package. The temporary nature of this change suggests that educational opinions are rather firmly anchored. This impression is reinforced by the fact that all three groups of earth science teachers in this study expressed essentially the same degree of progressivism at the end of the study that they had expressed at the beginning. Educational opinion, in the long term, seems to be a relatively stable teacher characteristic.

It is interesting, however, that the group which developed the new syllabus did express educational opinions which were significantly more progressive than those expressed by the other two groups. The source of this difference is a matter for speculation. It seems quite likely that teachers with more progressive outlooks volunteered for the arduous task of curriculum revision. It is possible, however, that the revision process did modify their opinions in a progressive direction. The effect of curriculum revision on the curriculum developers themselves presents an interesting subject for further investigation.

Analysis of hypotheses concerned with earth science knowledge indicates that, in general, a different set of concepts is being taught in classrooms using the new syllabus than was taught under the old syllabus. It should be noted, however, that despite a trend toward greater achievement on the "new content" subscore, students of teachers who changed syllabi in the course of the study did not perform significantly better on this test when their teachers were using the new syllabus than when they were using the old syllabus. It may be that this group of teachers needs more background in the newer concepts than is currently provided in the new syllabus package.

Since the new science curricula place so much stress on stimulating and developing student ability to recognize and apply science processes, the failure of the new earth science syllabus to significantly improve

achievement on the Processes of Science Test is particularly disappointing. There is some basis for believing that this instrument does not measure recognition and application of science processes with precision (cf. Wallace, 16). On the other hand, an evaluation of PSNS' effect on enhancing student process understanding, using Welch's Process of Science Measure, also failed to find significant differences attributable to the curriculum. (17) It thus seems quite likely that utilization of one of the new science curricula does not in itself bring about increased student knowledge of science processes. The conditions under which the new curricula are taught may very well determine the existence and the magnitude of this effect. For example, the stress which the teacher places on post-laboratory analysis of procedures used in the laboratory may turn out to be a critical condition for enhancing student knowledge of science process. Exploratory research is needed to identify potentially critical conditions.

This study's utilization of a dual design (cross-sectional and longitudinal) led to two results of particular interest. In the first place, the longitudinal portion of the study led to the finding that teachers did change their teaching strategies upon adoption of a new science curriculum. Secondly, when the results of both aspects of the study are compared, it appears that selection effects account for some of the difference between teaching behaviors employed by those using one of the new science curricula, and of those using a traditional curriculum. This suggests that care must be taken when interpreting the results of curriculum evaluations based on cross-sectional designs, particularly when random assignment to treatment and control groups is absent. If such randomization is not possible, utilization of a pre-post design should be considered.

Synopsis

This study investigated the effect voluntary or mandatory adoption of the Revised New York State Earth Science Syllabus had on instructional procedures, teacher educational opinion, student achievement in earth science, and student ability to employ the processes of science. Selection of teachers who were forced to adopt the new syllabus, voluntarily adopted the new syllabus, or who helped develop the new syllabus comprised the three experimental groups in this study (Group A, B, C respectively). Both cross-sectional (across groups) and longitudinal (pre-post) designs were employed to test the study's hypotheses. Data ~~was~~ were collected during the fall and spring of the 1970-71 and 1971-72 school years from students and teachers within the three groups. Adoption of the new syllabus did effect a change in instructional procedures, in the direction advocated by the developers of the new syllabus. However, Group A teachers did not employ teaching behaviors advocated by the new syllabus to the same degree that did teachers from Group B and C. Some fluctuations of teacher educational opinions did occur upon initial experience with the new syllabus, but overall this variable seemed to be relatively stable, with differences across groups being detected. Results of tests on the earth science content in the "old" and the "new" syllabus generally suggest that students preform best on the tests designed for the syllabus used by their teacher. Students of teachers in Group C did worse on the "old" content after adoption, but failed to do better on the "new" content. This study failed to detect any difference across groups or across time with respect to student ability to employ the processes of science.

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